Some Empirical Methods of Estimating Advertising Effects in Demand Systems: An Application to Dried Fruits

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Two different methods of incorporating advertising effects into Almost Ideal Demand Systems (AIDS) are presented. Both advertising schemes are designed to allow theoretical restrictions to hold globally rather than at particular sample points. The models are estimated for California figs, prunes, and raisins. Empirical results indicate that generic advertising effects for these three dried fruits are generally weak when compared to price and total expenditure effects. Estimated cross-commodity effects also are relatively small except for the negative effect of raisin advertising on the quantity of prunes demanded.

Key words: generic advertising, dried fruits, demand systems, cross-commodity effects.

United States farmers spend large sums on nonbrand commodity promotion through state and federal government-sponsored programs. Forker and Liu estimated, for example, that 1988 promotion expenditures by more than 80 farmer-financed commodity groups totaled well over half a billion dollars (p. 8). While the big promotional spenders are the national programs for dairy, beef, and pork ($300 million), important programs also are being conducted by state groups.

California specialty crop producers have a long history of group action under government enabling legislation, and 36 commodity organizations with advertising and promotion programs recently spent over $100 million to expand the demand for their products. One of the largest and most visible producer-funded promotional programs has been conducted by the California Raisin Advisory Board. In 1988–89 the Raisin Board allocated over $19 million

for its annual advertising and promotion budget. The Board's dancing raisins commercial was recognized by the advertising industry as the Most Popular Television Commercial of 1988. Other dried fruit producers, including figs ($478,000) and prunes ($7.6 million), are heavily engaged in promoting their commodities.

A long-standing and recurring question in any discussion of producer-funded advertising and promotional programs concerns the economic impact of promotional expenditures. Wolf, in a critique of commodity advertising programs, noted that ". . . data often have been worked up by interested parties to prove a biased case." He found no attempts to measure the effectiveness of advertising by analysis of shifting demand curves, inflation-adjusted grower income, or changing consumer expenditures. While there has been some progress in evaluating the impact of commodity promotion programs during the last 45 years, many questions remain unanswered. A growing collection of research results indicates that promotion can increase commodity demand, and there may be significant lagged effects in an advertising program. Little is known, however, about the impact of one commodity promo-

tion program on the sales of another commodity, or the degree to which producers benefit from their expenditures, or the importance of promotion relative to price and income effects. Further advances will require improved data and continued model development.

The purpose of this study is to specify analytical models for California dried fruit products that will enable us to determine the relative impacts of advertising, prices, and income while accounting for cross-commodity effects. This will be done by (*a*) incorporating advertising expenditures in the double-log specification and the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980a, b) and (*b*) estimating these models for California figs, prunes, and raisins.

Advertising in Demand Subsystems

Recent papers have incorporated advertising effects into demand systems (Cox; Duffy; Goddard and Amuah) using the specifications of the Rotterdam and Translog demand systems. In this study we report empirical results from two different demand systems. First, advertising effects are incorporated into the double-log model. Despite its well-known limitations (Deaton and Muellbauer 1980a, b), it is relatively easy to test for advertising effects, structural changes over time, and homogeneity restrictions within this framework. Second, two different methods of incorporating advertising effects into the AIDS of Deaton and Muellbauer (1980a, b) are developed. Both advertising schemes are designed to allow theoretical restrictions to hold globally rather than at particular sample points. This represents an extension of the specifications given in Green.

Consider the double-log demand system:

$$(1) \quad \ln q_i = \beta_0 + \sum_i \beta_i \ln p_{it} + \sum_i \delta_i \ln A_{it}$$
$$+ \theta_i \ln x_t + \epsilon_t,$$

where q_i represents per capita quantity demanded of good i, p_{it} represents the price of commodity i, A_{it} represents current advertising expenditures on commodity i, x_t denotes per capita total expenditures, and ϵ_t is the disturbance term for the ith equation. Lagged advertising expenditures can be incorporated easily into the demand model to generalize the specifications. Using this functional form, only

the homogeneity restriction can be imposed. Adding-up and symmetry conditions do not hold for the double-log model.

Next consider two methods of incorporating advertising effects into the AIDS. The first method is a special application of Ray's dynamic generalization of the AIDS. Consider the AIDS cost function:

$$(2) \quad \ln c(u, p_t)$$
$$= \alpha_0 + \sum_k \alpha_k \ln p_k + \sum_i \delta_i \ln A_{it} + \sum_i \theta_i \ln A_{it-1}$$
$$+ \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt} + u \beta_0 \prod_i p_{it}^{\beta_i},$$

where p_{it} represents the price of commodity i, A_{it} and A_{it-1} represent current and one-period lagged advertising expenditures, and u represents unobservable utility.[1,2] A generalized AIDS can be derived from (2) using Shephard's Lemma and substituting for u (e.g., Blanciforti, Green, and King; Ray). The generalized AIDS is

$$(3) \quad w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln \left(\frac{x_t}{p_t^*} \right),$$

where

$$\ln p_t^*$$
$$= \alpha_0 + \sum_k \alpha_k \ln p_{kt} + \sum_i \delta_i \ln A_{it} + \sum_i \theta_i \ln A_{it-1}$$
$$+ \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt},$$

and $w_{it} = p_{it} q_{it}/x_t$ denotes the ith budget share.

Adding-up restrictions require that $\sum_i \alpha_i = 1$, $\sum_i \gamma_{ij} = 0$, and $\sum \beta_i = 0$. Homogeneity requires $\sum_j \gamma_{ij} = 0$, and symmetry requires $\gamma_{ij} = \gamma_{ji}$. These conditions hold globally, that is, at every data point. Only sketches of the proofs of these three conditions are given in the appendix since they are similar to those found in Blanciforti, Green, and King.

The original AIDS is theoretically plausible

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but the modified system, with advertising effects incorporated, is in a technical sense only approximately theoretically plausible. The modified system satisfies the Slutsky symmetry conditions, homogeneity conditions, and adding up, but the substitution matrix need not be negative semidefinite except when all the advertising coefficients are sufficiently close to zero (see Pollak and Wales for a detailed discussion of this point).

A disadvantage of the above method of incorporating advertising into demand models is that advertising only affects demand through the "real" expenditure term, $\ln(x/p^*)$. A possible interpretation of this advertising scheme is that "own advertising" has a positive effect on market shares when p^* and A are inversely related. That is, when advertising increases, real income must increase. This interpretation may be erroneous, however, because β_i is negative for necessities, and it is not possible to sign δ_i and θ_i a priori. A major advantage of this model is that the demand restrictions hold globally.

Elasticity formulas for the generalized AIDS model incorporating advertising effects are:

(4)   Income: $\eta = 1 + \beta_i/w_i$;

(5)   Price:

$$\epsilon_{ij} = -\delta_{ij} + \left[\gamma_{ij} - \beta_i\left(\alpha_j^* + \sum_k \gamma_{ik}\ln p_k\right)\right] \Big/ w_i,$$

where $\delta_{ij} = 1$ if $i = j$, zero otherwise;

and

(6)   Short-Run Advertising: $\epsilon_{iA_{tj}} = -\beta_i\delta_j/w_i$,

and

$$\epsilon_{iA_{t-1,j}} = -\beta_i\theta_j/w_i.$$

An alternative method of incorporating advertising into the AIDS is similar to the method used by Duffy in the Rotterdam model. Consider the following cost function:

(7) $\ln c(u, p_i)$

$$= \alpha_0 + \sum_i \alpha_i(\ln p_{it} - \delta_i\ln A_{it}) + \frac{1}{2}\sum_i\sum_j \gamma_{ij}$$

$$\cdot(\ln p_{it} - \delta_i\ln A_{it})(\ln p_{jt} - \delta_j\ln A_{jt})$$

$$+ u\beta_0\prod_i p_{it}^{\beta i}.$$

By again applying Shephard's Lemma and sub-

stituting for u, the following AIDS is obtained:[3]

(8)
$$w_{it} = \alpha_i + \sum_j \gamma_{ij}(\ln p_{jt} - \delta_j\ln A_{jt})$$
$$+ \beta_i\ln (x/P^*),$$

where

$$\ln P^* = \alpha_0 + \sum_i \alpha_i(\ln p_{it} - \delta_i\ln A_{it})$$
$$+ \frac{1}{2}\sum_i\sum_j \gamma_{ij}(\ln p_i - \delta_i\ln A_{it})$$
$$\cdot(\ln p_j - \delta_j\ln A_{jt}).$$

The model can be extended easily to include additional lagged advertising terms.

The following restrictions hold globally for the above model:

(9)   Adding up: $\sum_i \alpha_i = 1$, $\sum_i \beta_i = \sum_i \gamma_{ij} = 0$,

(10)   Homogeneity: $\sum_j \gamma_{ij} = 0$, and

(11)   Symmetry: $\gamma_{ij} = \gamma_{ji}$.

Elasticity expressions for the linear approximate of the above generalized AIDS are given by:[4]

(12)   Income: $\eta = 1 + \beta_i/w_i$;

(13)   Price: $\epsilon_{ij} = -\delta_{ij} + [\gamma_{ij} - \beta_iw_j]/w_i$,

where $\delta_{ij} = 1$ for $i = j$, zero otherwise;

and

(14)   Advertising: $\epsilon_{iA_j} = -\gamma_{ij}\delta_j/w_i$.

An advantage of this model over the one given in (3) is that advertising affects demands in a direct way and also indirectly through the real income term. An alternative interpretation of this specification is that advertising operates on demand through the price terms. More specifically, the terms in parentheses in equation (8) can be written as $\ln(p_{jt}/A_{jt}^{\delta j})$. Algebraically, advertising expenditures can be thought of as a price deflator, although an intuitive interpretation is not obvious.

In the demand models weak separability of dried fruits from all other commodity groups

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[3] Please note that the effects of incorporating advertising in equation (7) are similar to those noted previously for equation (3).

[4] For ease of estimation, the linear approximate version of demand model (8) was used where Stone's index, $\ln P^* = \sum w_k\ln p_k$, replaces the price deflator given with equation (8). Thus, the elasticity formulas for the linear approximate AIDS are those that correspond to the estimations.

was assumed. As Pudney (p. 570) states, ". . . separability does not imply that between-group responses are necessarily small, only that they conform to a specific pattern." Weak separability allows the demand analyst to concentrate on the second branch of a two-stage budgeting process. While many different tests for weak separability exist, it is not obvious to the authors which of the myriad combinations of groups of commodities would be viable candidates in which to perform the tests. Furthermore, the focus of the article is on measuring advertising and cross-advertising effects and not on testing for separability conditions. Thus, the common but somewhat restrictive assumption of weak separability is invoked in all the demand models.

The Empirical Application

California dried figs, prunes, and raisins recently (1984–88) have accounted for an annual average of almost 92% of total U.S. dried fruit production. Each of the three commodities has a history of generic advertising under California State Marketing Order programs, and annual data on advertising expenditures were available for the 30 years from 1957 through 1986. None of the dried fruits accounting for the remaining 8% of U.S. production (apples, apricots, dates, peaches, and pears) has had government-sponsored advertising programs and, except for dates, the dried portion of the total crop is small. Dried fruits may be purchased directly by consumers, but large quantities are used as ingredients in processed products. Thus, opportunities for substitution among individual dried fruits and other possible inputs, such as fresh or frozen fruit, dried fruits and nuts, are difficult to determine.

As noted previously, collective promotional expenditures by dried fruit marketing order committees have been large, and they have grown substantially over time (figure 1). Total annual expenditures during the period of analysis ranged from a low of $820,000 in 1958 to a high of over $17.8 million in 1984. Total promotional expenditures during the 30-year period by commodity were: figs, $1.6 million; prunes, $44.6 million; and raisins, $111.5 million. Promotional expenditures by individual commodity varied substantially from year to year, as did each commodity's share of total expenditure. During the last five years of the

period, figs accounted for an average of 1% of total expenditures, while prunes and raisins accounted for 26% and 73%, respectively. Individual producers recently have paid assessments ranging from 2.2% to 3.3% of the gross farm value of their crops, and similar amounts have been collected from processors.[5] The long-term impact of these substantial promotional expenditures is of considerable interest to the producers and processors who provide the funds as well as to policy makers concerned with generic promotion of farm products.

The models specified in equations (2) and (7) were estimated using annual data for 1957–86. These data include annual advertising expenditures for each dried fruit (French, Tamimi, and Nuckton; California Department of Food and Agriculture, *Marketing Order and Council Programs' Budgeted Expenditures* reports); U.S. consumption of each dried fruit, pounds per capita (U.S. Department of Agriculture, *Fruit and Tree Nuts Situation and Outlook*); and grower prices, dollars per pound, dry weight[6] (California Crop and Livestock Reporting Service, *California Fruit and Nut Statistics*). The advertising and price data were converted to real terms using the Consumer Price Index (1982–84 = 100).

In the AIDS models we allowed for autocorrelation of the disturbances by assuming

$$(15) \qquad \qquad \epsilon_{it} = \rho \epsilon_{it-1} + u_{it},$$

where the u's are independently and normally distributed, i.e., $u \sim N(0, \sigma^2 I)$. The adding-up conditions in the AIDS models implies that the contemporaneous variance-covariance matrix is singular; consequently, one of the equations must be deleted (Barten). Iterative seemingly unrelated regression estimators are invariant with respect to the equation deleted since they are asymptotically equivalent to

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[5] Total marketing order assessments support all of the activities of each order, including such things as research and administration in addition to advertising and promotion. Recent producer assessments collected at the first-handler level were $21.50 per ton for dried figs, $25.50 per ton for prunes, and $26.00 per ton for raisins. Handlers also paid assessments of $21.50, $15.50, and $26.00 per ton, respectively, for the three commodities. The advertising and promotion expenditures include both producer and processor contributions. Note that we did not have access to data on brand advertising by individual firms, and therefore this activity is not included in our analysis.

[6] Fig and raisin prices were reported dry basis; prune prices were converted to dry basis using a conversion factor of 2.7 pounds fresh to one pound dry. All prices were converted from dollars per ton to dollars per pound.
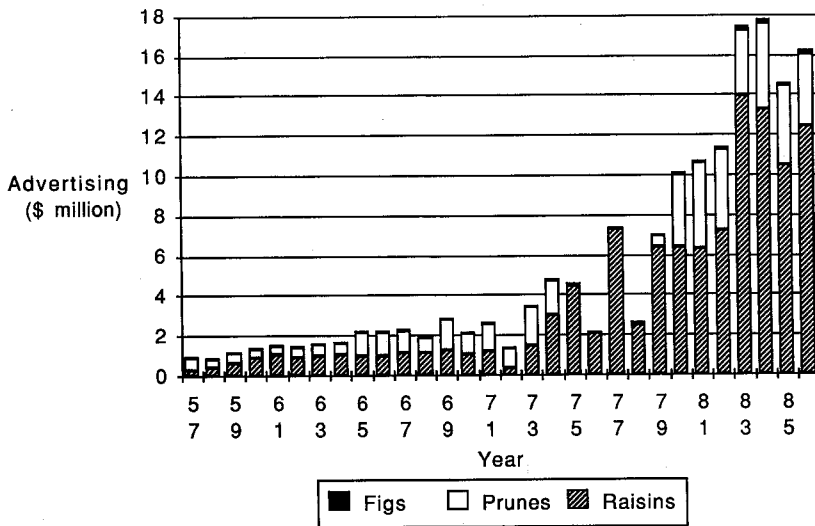
Figure 1. Annual generic advertising expenditures for California dried fruits, 1957-86

maximum likelihood estimators (Judge et al.). Furthermore, each model was estimated with different starting values in order to avoid problems with multiple local optima. In all models the computer program SHAZAM, version 6.1, was used.

First, consider the empirical results from the double-log demand model in equation (1). Seemingly unrelated regression estimators are obtained, but they are equivalent to least squares estimators since the equations contain the same right-hand-side variables. Only current advertising expenditures are included since the F-tests failed to reject the null hypothesis that all lagged advertising coefficients are zero; the F-statistics for the fig, raisin, and prune equations were 2.294, 1.748, and 2.99, respectively. Similar F-values yielded statistically significant results at the 5% level of significance for the current advertising coefficients; the F-statistics were 6.57, 19.41, and 14.45, respectively, for figs, raisins, and prunes. Given that we are using annual data, these results appear reasonable.[7]

Overall the R^2s for the fig, raisin, and prune equations for the double-log functional form were, respectively, .73, .95, and .77. There was no indication of problems with autocorrelation given Durbin-Watson statistics of 1.29, 1.59, and 1.99 for the fig, raisin, and prune equations.

In table 1, all the own-price elasticities are negative, only the current own-advertising elasticity for raisins is positive, and all the total dried fruit expenditure elasticities are positive. Of the nine price elasticities, five have associated t-ratios greater than two in absolute value. Five of the advertising coefficients have t-values greater than two in absolute value. The primary empirical result is that the total expenditure and price elasticities are much larger, in an absolute sense, in almost every case than their estimated advertising elasticity counterparts.[8]

The estimated autocorrelation coefficient for the model in (3) was not significantly different from one ($\hat{\rho} = 1.000$ with an asymptotic $t = 7,112.5$) using the SHAZAM computer program. This implies a unit root with an infinite variance for the equation disturbance term.

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[7] A reviewer pointed out that simultaneous equation bias problems may exist unless the supply curves for dried fruit are perfectly elastic. This statement applies to both the double-log and AIDS functional forms. This is true for all systems of demand equations. A possible solution, without modeling the supply side with the demand systems, is to use instrumental variables estimation procedures to account for the endogeneity of some of the explanatory variables. This approach is beyond the scope of the present research.

[8] Since the data covers the period 1957 to 1986, "Chow" and "Farley-Hinich" tests were performed for structural changes. Both sets of tests indicated that structural changes indeed had occurred; however, the relative magnitudes of the price and income elasticities relative to advertising elasticities do not change in the double-log model. Thus, these results are not reported here.

Table 1. Price, Advertising, and Total Expenditure Elasticities for the Double-Log Model

Commodity	Price			Advertising			Total Expenditure
	ϵ_{i1}	ϵ_{i2}	ϵ_{i3}	$\epsilon_{Ai,1}$	$\epsilon_{Ai,2}$	$\epsilon_{Ai,3}$	η
Figs	−.228	−.778	.093	−.103	−.171	−.075	.913
	(.255)	(.366)	(.229)	(.059)	(.103)	(.042)	(.399)
Raisins	−.067	−.668	−.203	.029	.093	.021	.938
	(.055)	(.079)	(.049)	(.013)	(.022)	(.009)	(.086)
Prunes	−.036	−.607	−.346	−.012	−.252	−.046	.990
	(.127)	(.182)	(.113)	(.029)	(.051)	(.021)	(.198)

Note: The homogeneity condition was imposed in the estimations. Values in parentheses are standard errors.

The model also was estimated using SAS; however, two of the three total expenditure elasticity estimates were negative and one of the three own-price elasticity estimates was positive. Thus, while the conceptual framework for incorporating advertising in the AIDS in (3) is sound, we were unsuccessful in obtaining meaningful elasticity estimates with this particular data base.

Empirical results for the linear approximate AIDS incorporating advertising effects through the price terms in equation (8), and similar to Duffy's approach, are reported in tables 2, 3, and 4.[9] All of the reported elasticity estimates in tables 2, 3, and 4 are second-stage or conditional elasticity estimates as in the double-log demand case. That is, the three commodities—figs, raisins, and prunes—are assumed to be weakly separable from other commodities, and total aggregate expenditures on these commodities are assumed to be given.

First, consider the tests of the theoretical restrictions. Based on the likelihood ratio procedure, homogeneity and symmetry conditions are strongly rejected; see table 2. Since there tends to be overrejection of the restrictions in small samples, Anderson's procedure was used to adjust the likelihood ratio statistic; see column 2 in table 2.[10] However, the homogeneity and symmetry conditions continue to be rejected after approximate adjustments for sample size. There are several possible ex-

planations for this result including the obvious one that the modified AIDS may not be the proper parametric demand specification. However, rejection of demand restrictions is a phenomenon that applied demand analysts frequently encounter. In addition, we tested the null hypothesis that all the advertising coefficients are simultaneously equal to zero. A likelihood ratio value of 3.19 was much less than $\chi^2_{6.05} = 12.59$. Thus, generic advertising taken as a whole did not have a statistically significant effect on the demand for dried fruits. This result differs from that obtained for the double-log demand model where partial F-tests yielded statistically significant current advertising effects in every case at the 5% level.

Price and total expenditures elasticity estimates are reported in table 3. All own-price elasticity estimates are negative. The values for figs, raisins, and prunes are, respectively, −.941, −.784, and −.500. The total expenditure elasticities are .751, .976, and .849. In every case these values, in an absolute sense, are larger than the short-run current and one-period lagged advertising coefficients reported in table 4. These results are similar to those found for the double-log models.

The advertising cross-elasticity effects for both current and one-period lagged estimates are sometimes asymmetric, a result that is not inconsistent with demand theory. For example, an increase in current advertising expenditures for raisins decreases the quantity demanded for figs while an increase in current advertising expenditures for figs increases the quantity demanded for raisins (table 4, columns 2 and 3). In general, the cross-advertising and the own-advertising elasticity estimates are quite small relative to the price and expenditure elasticities.

The main policy implication from these re-

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[9] Including current advertising effects also can create serious simultaneity problems especially for generic advertising programs which assign fixed advertising and promotion fees based on current production. Attempts to obtain meaningful iterative three-stage least squares estimates were unproductive. In addition, to avoid the simultaneity problem, only lagged advertising effects were included, and the basic results were similar to those presented for the models including current as well as lagged advertising effects.

[10] Also see Anderson and Blundell; Pudney; and Simmons.

Table 2.   Test Results for the Linear Approximate AIDS

Restriction	Test Statistic $-2 \ln \lambda$	Test Statistic with Correction[a]	Critical χ^2 Values	
			$\chi^2_{.05}$	$\chi^2_{.01}$
Homogeneity (H)[b]	41.44	29.29	5.99	9.21
Homogeneity, Symmetry (H & S)	17.06	12.21	7.81	11.35
H, S, All Adv. Coeff. Same	19.74	14.81	14.07	18.48
Symmetry (S)[c]	24.40	17.88	3.84	6.63
All Adv. Coeff. Same[d]	2.67	2.05	9.49	13.28

[a] The likelihood ratio statistic was corrected by the method discussed in Anderson, pp. 208–09.
[b] The first three restrictions were tested against the unrestricted AIDS model.
[c] Symmetry conditions were tested against the model with homogeneity imposed.
[d] The restriction that all the advertising coefficients are equal was tested against the model with homogeneity and symmetry restrictions also imposed.

sults, given the empirical econometric limitations, is that generic advertising exerts relatively weak effects on the demand for dried fruits relative to price and total expenditure effects. These results are consistent with those obtained by Duffy for alcoholic drinks in the United Kingdom using the Rotterdam model. One must be careful, however, to avoid equating the size of the advertising elasticity with the potential returns from advertising since these returns are determined by several factors including product price, the elasticity of supply and demand, the level of advertising, the cost of additional output, and the advertising elasticity. This can be illustrated with a simple example based on raisins. Raisin advertising totaled $16.25 million in 1986, and the total farm value for raisins was about $203 million. Using an advertising elasticity of .10, an increase in advertising of $1 million (6.15%) would lead to a predicted consumption increase of .615%, which would increase total revenues from $203 million to $204.25 million, holding prices constant (perfectly elastic supply). Thus, given a surplus (reserve tonnage), the industry could increase total revenues by advertising, despite the small elasticity estimate.

Other specifications also were estimated in addition to the double-log and the two AIDS models. The Rotterdam and Translog models were estimated including advertising effects. However, both of these specifications yielded some positive own-price elasticity estimates and thus these results are not reported here.

Conclusions

This study developed and estimated two theoretically consistent methods of incorporating advertising effects into demand subsystems. Results of estimating the double-log and AIDS models for California dried fruits (raisins, figs, and prunes) generally were similar but with some differences in the magnitude and signs of individual estimated coefficients. Demand is inelastic at the producer level for each of the three products, and each has a positive expenditure elasticity (ranging from .75 to .99).

Serious weaknesses in data, including the length of the period of analysis, aggregation, and the nature of the advertising variable dictated the use of a very simple model. Thus, empirical results which were in a few instances contradictory must be viewed with some caution. With this warning in mind, however, the estimated advertising elasticities permit several tentative conclusions regarding the impact of advertising on the demand for dried fruits. First, an important result of the analysis, based on the model in equations (1) and (8), is the finding that generic advertising effects for rai-

Table 3.   Price and Total Expenditure Elasticities for the Linear Approximate AIDS

Commodity	Price			Total Expenditures
	ϵ_{i1}[a,b]	ϵ_{i2}	ϵ_{i3}	η
Figs	−.941	.099	.090	.751
Raisins	−.006	−.784	−.186	.976
Prunes	−.002	−.648	−.500	.849

Note: The linear approximate AIDS of equation (8) was estimated with homogeneity and symmetry conditions imposed. The autocorrelation estimate was .284 with an associated t-value of 1.94.
[a] The elasticity expressions are given in equations (12) and (13).
[b] To compute standard errors, bootstrap methods could be used (a tedious procedure) or alternatively a common practice is to assume that the endogenous budget shares are exogenous. We prefer not to report standard errors than to use the latter technique.

Table 4. Short-Run Current and One-Period Lagged Advertising Elasticities

Commodity	Current Advertising			Lagged Advertising		
	$\epsilon_{Ai,1_t}$[a]	$\epsilon_{Ai,2_t}$	$\epsilon_{Ai,3_t}$	$\epsilon_{Ai,1_{t-1}}$	$\epsilon_{Ai,2_{t-1}}$	$\epsilon_{Ai,3_{t-1}}$
Figs	−.142	−.029	.000	−.067	−.007	.001
Raisins	.030	.083	−.001	.014	.020	−.005
Prunes	−.039	−.226	.001	−.018	−.055	.014

Note: The linear approximate AIDS of equation (8) was estimated with homogeneity and symmetry conditions imposed. The autocorrelation estimate was .284 with an associated t of 1.94.
[a] Elasticity expressions are given in equation (14).

sins, figs, and prunes generally are weak when compared to price and total expenditure effects. In fact, there is no empirical evidence in this study that advertising for figs has had any positive impact on the demand for figs. While raisin advertising programs appear to have increased the demand for raisins, these results indicate that an approximate 10% increase in advertising expenditures is required to increase the quantity of raisins demanded by 1%. As illustrated, even this small response may be profitable, depending on such factors as level of advertising, crop values, costs, and the existence of reserve tonnage. The cross-commodity effects of advertising also were relatively small except for the effect of raisin advertising on the quantity of prunes demanded. Here the current short-run cross-advertising elasticities of −.226 (table 4) for the model indicates that a 1% increase in advertising for raisins reduced the quantity demanded of prunes by .23%.[11] These cross elasticities are much larger than the own-advertising elasticity for prunes (.001), indicating that prune producers may have a difficult time overcoming the negative impact of increased raisin advertising on the demand for their product.

While not entirely definitive, study results do provide support to the hypothesis that non-brand advertising can have important cross-commodity impacts. This raises the question of the appropriate role of the Secretary of Agriculture and the Agricultural Marketing Service in developing and approving promotional programs for one agricultural sector that work to the disadvantage of another. The related questions of constant long-run market share with advertising as a built-in cost and the possible consumer impacts also are relevant.

Finally, we endorse the long-standing call for improved analysis of the economic impacts of agricultural commodity promotion programs, a task that will require increased attention to better data collection. One would expect, for example, that careful collection of more frequent observations (quarterly, monthly, or weekly) by type of advertising together with sales and prices for sets of competing commodities would enable analysts to develop improved estimates of direct and cross-advertising elasticities and better validate their economic models.

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[11] For the double-log model, the cross-advertising elasticity of raisins on prunes is −.252, table 1.

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Appendix

Adding up

To see what this restriction implies, sum both sides of (3) over i, i.e.,

$$\sum_i w_{it} = 1 = \sum_i \alpha_i + \sum_i \sum_j \gamma_{ij}\ln p_{jt} + \sum_i \beta_i\ln\left(\frac{x_t}{P_t^*}\right).$$

If the sum of the budget shares equals one for each data point, then $\sum_i w_{it} = 1$ implies that $\sum_i \alpha_i = 1$, $\sum_i \gamma_{ij} = 0$, and $\sum_i \beta_i = 0$.

Homogeneity

To show that the demand function in (3) is homogeneous of degree zero in current prices and expenditures, first write the equation in quantity form. That is,

$$q_{it} = \frac{x_t}{p_{it}}\left\{\alpha_i + \sum_j \gamma_{ij}\ln p_{jt} + \beta_i\ln\left(\frac{x_t}{P_t^*}\right)\right\}.$$

Then show that $q_{it}(kp', kx_t) = q_{it}(p', x_t)$, where p is a vector of current prices, when $\sum_i \gamma_{ij} = 0$. Also note that the adding-up restrictions must hold for the demand function in (3) to be homogeneous of degree zero in current prices and expenditure.

Symmetry

Slutsky's symmetry condition states that the compensated cross-price derivatives are equal. To show that these restrictions hold if $\gamma_{ij} = \gamma_{ji}$, take the derivative of q_{it} with respect to p_{jt} and add the income term $q_{jt}(\gamma q_{it}/\gamma x_t)$. It can be shown that this expression equals $\partial q_{jt}/\partial p_{it} + q_{it}(\partial q_{jt}/\partial x_t)$, if $\gamma_{ij} = \gamma_{ji}$.